Advanced Buildings PEM FC Project

DOE Hydrogen, Fuel Cell, and Infrastructure Technologies Program Review Meeting

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IdaTech, LLC

May 25,2004

This presentation does not contain any proprietary or confidential information

Sempra Energy

Marriott HOTELS & RESORTS

GORE Creative Technologies Worldwide

CSA

PSE PUGET SOUND ENERGY

HYDROGENICS

PORTLAND STATE UNIVERSITY.

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Programmatic Objectives

- To demonstrate **high electrical and overall efficiency**, reduced energy consumption, and reduced emissions for hotel and follow-on applications.
- To **overcome technical and cost barriers** through the engineering, design and construction of an integrated system utilizing advanced fuel cell, fuel processor, and balance of plant subsystems.
- To **validate a 50 kW PEM fuel cell system** design through field testing at three separate properties to be co-selected by Marriott International, Sempra Utilities and Puget Sound Energy.
- To use the information provided from this demonstration to target early **market entry opportunities**.

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Project Budget

Phase Description	$ Federal	$ Cost Share (35%)	$ Total
Feasibility (Phase 1) Complete	484,336	260,812	745,178
Engineering (Phase 2)	2,575,867	1,387,005	3,962,872
Construction (Phase 3)	2,615,334	1,408,257	4,023,591
Field Evaluation (Phase 4)	591,024	318,244	909,268
Total	6,266,591	3,374,318	9,640,908

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DOE Technical Targets

50 – 250 kW Range

Table 3.4.6 Technology Targets: Integrated Stationary PEMFC Power Systems.

Characteristics	Units	2003	2005	2010
Electric Efficiency (Rated Power)	%	30	32	40
CHP Energy Efficiency (Rated Power)	%	70	75	80
Cost (200 units / yr → 5000 units / yr)	$/kWe	2500	1250	750
Durability (10% Degradation)	Hour	15k	30k	40k

31%

71%

2680

12k

Note: Additional Characteristics Are Identified in DOE's Technical Plan

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DOE Technical Barriers

3.4.4.2 Barriers

Dist Generation Barriers

E. Durability → MEA Life
F. Heat Utilization → Condensing heat exchangers
G. Power Electronics → High Efficiency, Low Cost, Water Cooled

Fuel Flexible Fuel Processor Barriers

J. Durability → Sulfur Handling, Catalyst Longevity
K. Emissions → Using "top of class" Commercial Combustion Equipment
L. Hydrogen Purification → Proven PSA technology
M. Integration and Efficiency → Approaching Theoretical Values
N. Cost → Industrial Catalysts and Material Optimization

Component Barriers

O. Stack Material and Manufacturing Costs → Molded Plates
P. Durability → BOP, Sensor Reduction, System Simplification
R. Thermal and Water Management → Non water-based cooling

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Approach (technical)

System Modularity by Function

Fuel Treatment Module
Fuel Processor Module
Fuel Cell Power Module
Thermal Module

- Reversible Sulfur Adsorbing Cycle
- Low Cost Water Treatment
- High Recovery Pressure Swing Adsorption System

- Scale Up From Existing 5 kW Reactor Geometry
- Industrial Catalyst and HEX Design
- ASME and CE Stamped Pressure Vessels

- Scale Up From Existing 10 kW Power Module
- Long Life MEA Optimization (Configuration and Operation)
- Power Electronics

- Fuel Cell Temperature Control
- Condensing Heat Exchangers
- Low Pressure Drop

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Approach (markets)

- **Hotels as the "Beachhead Segment"**
  - High utilization capacity of electrical and thermal load.
  - Corporate energy managers with the strategic vision and resources to validate and deploy new technologies.
  - Resulting product will be applicable to many follow on markets:
    - Government and Military Buildings, Hospitals, Prisons, Multi-Dwelling, Laundry Facilities.

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Project Safety

- **Infrastructure Improvements**
  - Installed Redundant CO, Combustible Gas and H2 detectors.
  - Explosion Proof Development Ventilation System.
  - Vacuum Loss Interlocks on all Ventilation Systems.
  - Emergency Stop Switches For All Energy Sources.

- **Design Safety Process Procedures**
  - HAZOP analysis (POC, Alpha, and Beta Stages).
  - FMEA (Failure Mode Effect Analysis).
  - ECO (Engineering Change Order) at Beta Stage.
  - CSA Product Rating

- **Design Documents**
  - NFPA 853
  - CSA FC1

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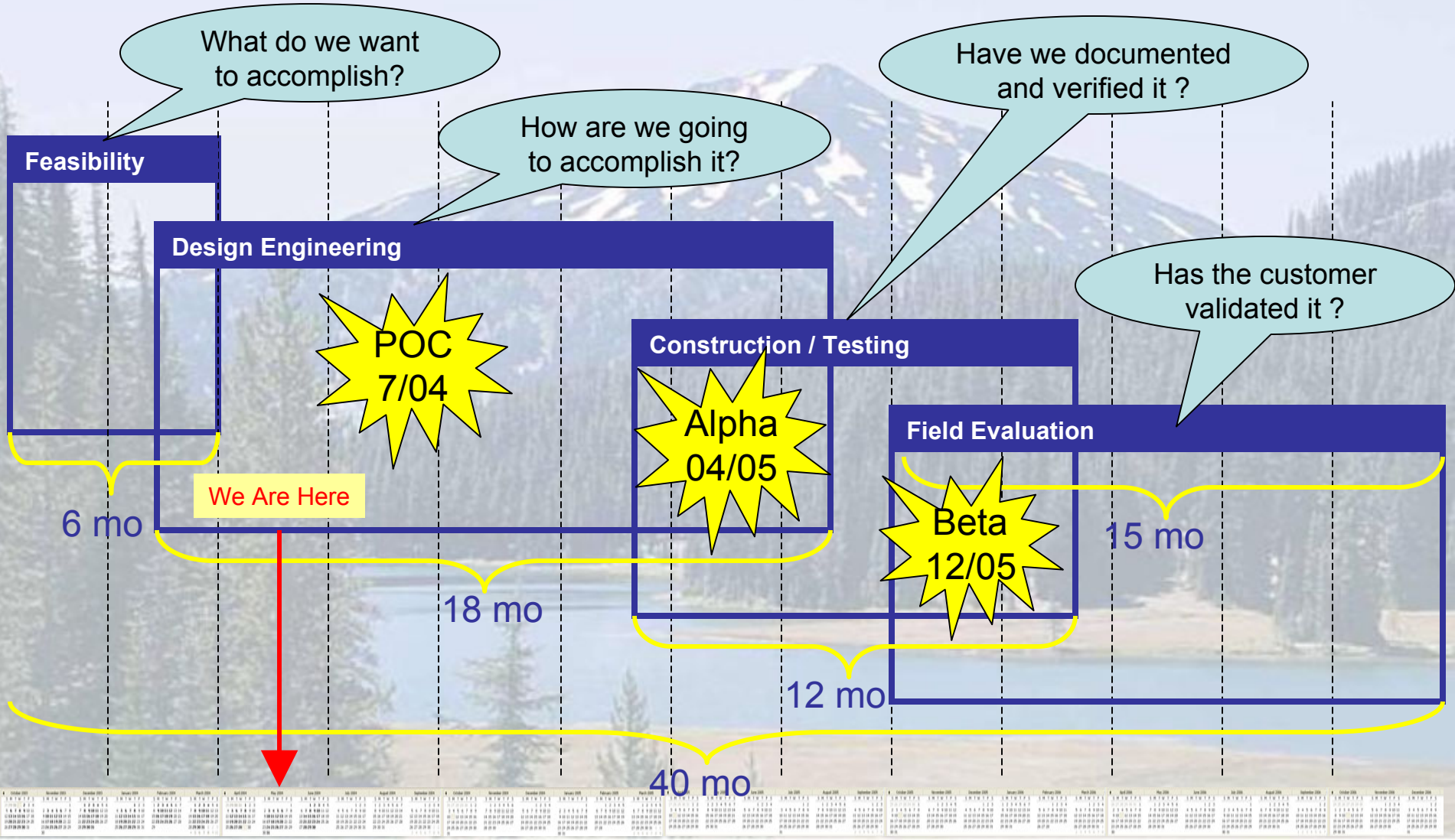
Project Timeline



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Feasibility Phase Objectives

Phase 1) Feasibility Study:

To define and communicate the project expectations, targets and functional requirements to all project stakeholders.

Task 1: Feasibility Engineering	
Actions / Milestones	**Deliverables**
Develop Site Selection Criteria	Special and Quarterly Reports
Develop **F**unctional **R**equirements **S**pecification	Publish **F**unctional **R**equirements **S**pecification
Develop System Model	Publish **P**rocess **F**low **D**iagram's
Identify Candidate Sites	Integrated Product Team Meeting

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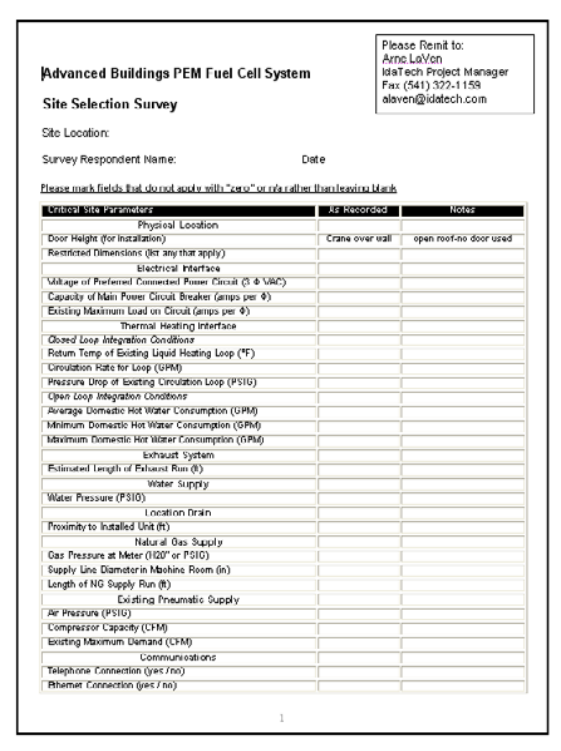
Technical Progress

Site Selection Criteria



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Advanced Buildings PEM Fuel Cell System

Site Selection Survey

Site Location:

Survey Respondent Name: Date

Please mark fields that do not apply with "zero" or n/a rather than leaving blank

Critical Site Parameters	As Recorded	Notes
Physical Location		
Door Height (for installation)	Crane over wall	open roof-no door used
Restricted Dimensions (list any that apply)		
Electrical Interface		
Voltage of Preferred Connected Power Circuit (3 Φ VAC)		
Capacity of Main Power Circuit Breaker (amps per Φ)		
Existing Maximum Load on Circuit (amps per Φ)		
Thermal Heating Interface		
Closed Loop Integration Conditions		
Return Temp of Existing Liquid Heating Loop (°F)		
Circulation Rate for Loop (GPM)		
Pressure Drop of Existing Circulation Loop (PSIG)		
Open Loop Integration Conditions		
Average Domestic Hot Water Consumption (GPM)		
Minimum Domestic Hot Water Consumption (GPM)		
Maximum Domestic Hot Water Consumption (GPM)		
Exhaust System		
Estimated Length of Exhaust Run (ft)		
Water Supply		
Water Pressure (PSIG)		
Location Drain		
Proximity to Installed Unit (ft)		
Natural Gas Supply		
Gas Pressure at Meter (H2O" or PSIG)		
Supply Line Diameter in Machine Room (in)		
Length of NG Supply Run (ft)		
Existing Pneumatic Supply		
Air Pressure (PSIG)		
Compressor Capacity (CFM)		
Existing Maximum Demand (CFM)		
Communications		
Telephone Connection (yes / no)		
Ethernet Connection (yes / no)		

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Functional Requirements

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Functional Requirements Specification

CM50

I

Jan.29, 2003

Submitted By:

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Submitted to: Project Siting Partners and Developers

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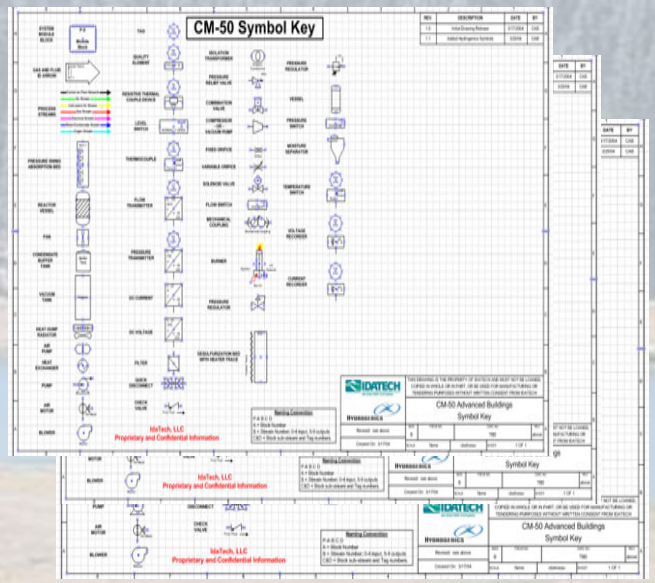
Candidate Sites

Process Flow Diagrams



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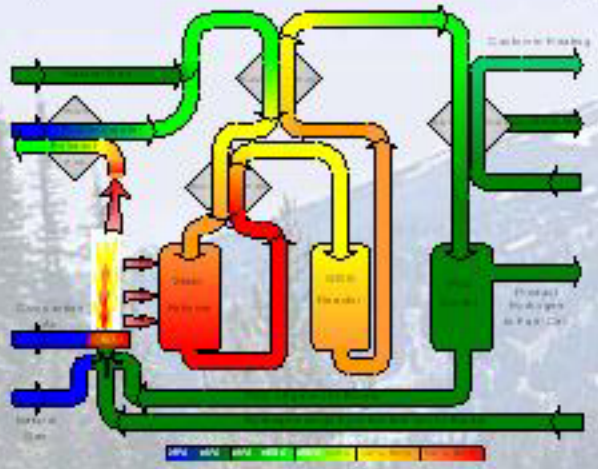
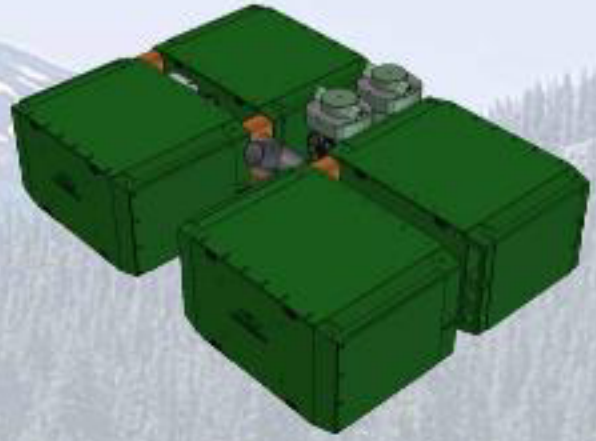
Technical Progress

System Process Modeling



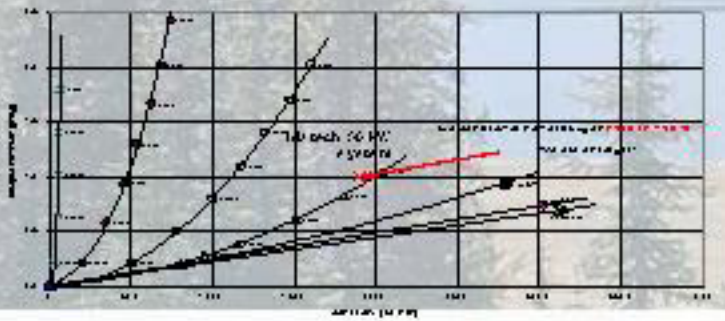
Dynamic Modeling

Physical Modeling



Balance of Plant Testing

(parasitic power reduction)



Catalyst / Sulfur Adsorbent Testing

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Interactions and Collaborations

HYDROGENICS CORPORATION

Technical Subcontractor – Development of FCPM

PORTLAND STATE UNIVERSITY

Beta Demonstration Siting Partner

Marriott HOTELS & RESORTS

Beta Demonstration Siting Partner

PSE PUGET SOUND ENERGY

Northern Utility Siting Partner

Sempra Energy

Southern Utility Siting Partner

CSA

Safety and Agency Approval Partner

Future Work

Phase 2) Design Engineering:

Design verification of four system sub-modules: (FTM, FPM, FCPM, and TMM) using a proof of concept and Alpha development cycle. Alpha modules are integrated into a complete prototype system (aCM50) to be used for controls development and long term testing.

Task 2: Design Engineering	
Actions / Milestones	**Deliverables**
Proof of Concept Design	Special and Quarterly Reports
POC Test Data / Design Review	HAZOP Reports
Alpha Design	Code Compliance Review
Alpha Test Data/ Design Review	Integrated Product Team Meeting

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